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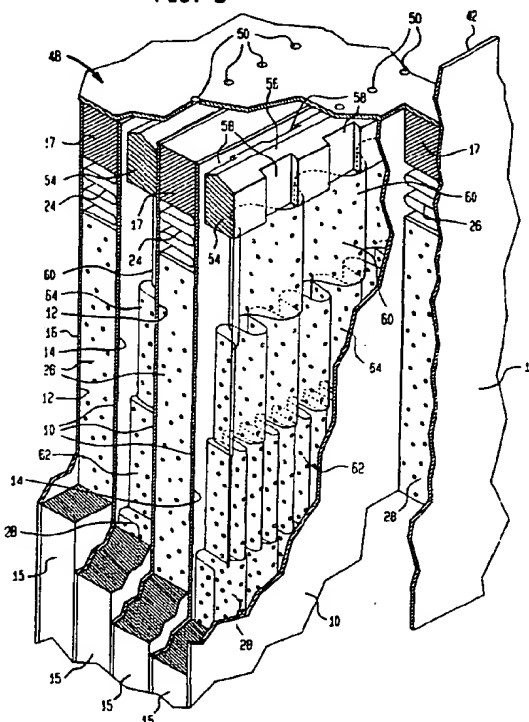
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(54) Heat exchanger of falling film type

(57) A heat exchanger for exchanging heat between first and second fluids has plurality of vertically oriented first and second passages 12 and 14 which are defined between alternating first and second passage walls 10. The first and second passages 12 and 14 bring the first and second fluids into a heat transfer relationship. The first passages 12 are associated with an inlet manifold 20 and an outlet manifold 34, for instance, to admit gaseous nitrogen into the top of the first passages 12 and to discharge condensed nitrogen from the bottom of the first passages 12. An inlet manifold 44 is provided to introduce the second fluid in liquid state into the second passages 14. A liquid film is distributed within the second passages 14 by way of an arrangement of slotted dividing bars 54 having staggered slots 58 along their length to urge liquid against the walls 10 defining the second passages. Additionally, or in place of the dividing bar arrangement, a plural-domain corrugated fin material arrangement comprising upper corrugated fin material 60 and lower corrugated fin material 62 can be provided to effect a liquid film distribution within the second passages. The lower corrugated fin material 62 has a higher density than the upper material 60.

FIG. 3



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Description

The present invention relates to a heat exchanger of the type known as a downflow reboiler or a falling film evaporator in which heat exchange takes place between two fluids flowing within adjacent, alternating heat exchange passages.

Downflow reboilers, also known as falling film evaporators, are used as a vehicle for indirectly transferring heat between two fluids, generally a liquid and a vapour. Such heat exchangers are often constructed from a plurality of parallel plates to form alternating heat exchange passages to indirectly exchange heat between the two fluids. In case of heat transfer to a liquid, heat transfer efficiency is realised by producing a descending liquid film within the heat exchange passages provided for the liquid. In order to further increase efficiency, the heat exchange passages can be filled with sheets of corrugated fin material to form vertically oriented channels within the heat transfer passages. Such channels increase the surface for the flow of the liquid film and therefore, the active area through which heat exchange can take place.

Obviously, to the extent liquid simply falls through the heat exchange passages without ever having formed a film, heat exchange efficiency will be lost. Additionally, the full potential of heat exchange efficiency of such a heat exchanger will not be realised to the extent a liquid film does not form within the channels provided by the corrugated fin material.

As will be discussed, the present invention provides liquid film distribution apparatus to enhance the formation and maintenance of liquid film within heat exchange passages and channels formed by corrugated fin material located within heat exchange passages.

According to a first aspect the present invention provides a heat exchanger for exchanging heat between first and second fluids, said heat exchanger comprising:

a plurality of vertically oriented, spaced apart passage walls defining a plurality of alternating first and second passages located between said passage walls to receive respectively said first and second fluids in an indirect heat transfer relationship;

first inlet and outlet means for respectively introducing and discharging said first fluid into and from said first passages;

second inlet means for introducing said second fluid into said second passages as a liquid;

slotted dividing bars located between said passage walls defining said second passages, said slotted dividing bars having spaced, vertically oriented slots to cause said liquid to flow against said passage walls defining said second passages, thereby to enhance formation of liquid film on said passage

walls; and

second outlet means for discharging said second fluid from said second passages after having indirectly exchanged heat with said first fluid.

According to a second aspect the present invention provides a heat exchanger for exchanging heat between first and second fluids, said heat exchanger comprising:

a plurality of vertically oriented, spaced apart passage walls defining a plurality of alternating first and second passages in indirect heat exchange relationship with one another for receiving said first and second fluids, respectively;

first corrugated fin material located within the first and second for forming vertically oriented channels for downflow of liquid film;

first inlet and outlet means for respectively introducing and discharging said first fluid into and from said first passages;

second inlet means for introducing said second fluid into said second passages as a liquid;

at least two sections, located above said vertically oriented channels and within said second passages, respectively containing second and third corrugated fin material;

said second corrugated fin material located above said third corrugated fin material;

said third corrugated fin material having a corrugation density higher than that of said second corrugated fin material and no greater than that of said first corrugated fin material to distribute said liquid film into said vertically oriented channels located within said second passages; and

second outlet means for discharging said second fluid from said second passages after having indirectly exchanged heat with said first fluid.

As will be discussed the present invention also comprehends using both of the foregoing aspects in conjunction with one another so that liquid film formation and the distribution of the liquid film is enhanced. It is to be noted that the term "density" as used herein and in the claims means the number of folds or corrugations within the corrugated fin material per unit length of material.

A heat exchanger according to the invention will now be described, by way of example, with reference to the accompanying drawing, in which:

Figure 1 is a sectional view of a heat exchanger in accordance with the present invention taken along line 1-1 of Figure 2;

Figure 2 is a sectional view of Figure 1 taken along line 2-2 of Figure 1; and

Figure 3 is a fragmentary, perspective view of a heat exchanger in accordance with the present invention with portions broken away in order to show internal components of such heat exchanger.

With reference to the drawings, a heat exchanger 1 in accordance with the present invention is illustrated. Heat exchanger 1 is designed to be used in connection with a sump. The sump can simply be a tank enclosing heat exchanger 1 or a sump, for instance, in a lower pressure column of a double distillation column, designed to receive liquid oxygen.

Heat exchanger 1 is configured to exchange heat between first and second fluids which can be gaseous nitrogen and liquid oxygen. To this end, the plurality of vertically oriented, spaced apart passage walls 10 are provided to define a plurality of alternating first and second passages 12 and 14, respectively. Passage walls 10 are sandwiched between vertically oriented dividing bars 15, thereby to seal first and second passages 12 and 14 at their lateral edges. The sides of heat exchanger 1 are formed by sidewalls 16 which are joined at their lateral edges to vertical dividing bars sealing the outermost of first passages 12.

First passages 12 are sealed at the top and bottom by top and bottom dividing bars 17 and 18, respectively located at the top and bottom of first passages 12. A first fluid, for instance, gaseous nitrogen to be condensed, enters a first inlet manifold 20 having an inlet opening 22. For exemplary purposes, the gaseous nitrogen having entered inlet manifold 20 is then conducted in a horizontal direction by horizontally oriented, corrugated fin material 24. Inclined corrugated fin material 26 conducts the horizontal flow of nitrogen to a more vertical direction for reception in first passages 12. In order to increase surface area for heat transfer, each of the first and second passages contain a first corrugated fin material 28. After condensation within first passages 12, the resulting liquid is deflected to the horizontal from the vertical by provision of inclined corrugated fin material 30 and horizontally oriented corrugated fin material 32. Liquid nitrogen is then discharged from first passages 12 by provision of a first outlet manifold 34 having a discharge opening 36.

First inlet manifold 20 and first outlet manifold 34 are connected to vertically oriented dividing bars 15. As illustrated, the vertically oriented dividing bars 15 used in sealing first passages 12 are staggered to allow the first fluid to enter first passages from first inlet manifold 20 and thereafter, to be discharged from first passages 12 to first outlet manifold 34.

A second fluid (that for purposes of illustration can be liquid oxygen) enters a reservoir 42 through a second inlet manifold 44 having an inlet opening 46. Reservoir 42 is formed, on one side, by second inlet manifold 44 and, on the opposite side by an end plate 47. Sidewalls 16 are sized to extend above first and second passages 12 and 14 to form the transverse sides of reservoir 42. Liquid flows through a perforated base plate 48 having openings 50 to second passages 14 where the liquid descends as a film and undergoes indirect heat exchange with the first fluid passing within first passages 12. As illustrated, second passages 14 are open at the bottom of heat exchanger 1 to allow liquid that has not been vaporised to fall into a sump not shown to be used in connection with the illustrated embodiment of heat exchanger 1. (Alternatively, an outlet manifold (not shown) may be provided so as to conduct the liquid from the second passage 14. Thus, although not illustrated, dividing bars 15 used in connection with second passages 14 extend the full length of second passages 14.

With additional reference to Figure 3, liquid passing through openings 50 falls onto slotted dividing bars 54, each of which may have a lengthwise extending peak 56. An alternate arrangement of staggered slots 58 defined within the sides of each of dividing bar 54 allow liquid to flow downwardly and against passage walls 10 to initiate liquid film production. It is understood that peaks 56 could be omitted and as such, the top of slotted dividing bars 54 could be flat. In any embodiment of dividing bars 54, the staggering of slots 58 ensures that liquid coverage will be along the entire length of each second passage 14 so as to fully utilise it.

As mentioned above, first corrugated fin material 28 is provided in both first and second passages 12 and 14. The corrugations of first corrugated fin material 28 produce vertical channels within each first and second passage 12 and 14. In order to produce film formation on as many of such vertical channels as possible, second, third, and fourth corrugated fin materials 60, 62 and 64 can be provided to further distribute liquid film initiated at slotted dividing bars 54. Second corrugated fin materials 62 is less dense than underlying third corrugated fin material 64. Fourth corrugated fin material 64, interposed between first and second corrugated fin materials 60 and 62, is more dense than first corrugated fin material 60 but less dense than second corrugated fin material 62. This arrangement of corrugated fin materials ensures that the descending liquid film becomes increasingly more divided during its descent through these sections of corrugated fin materials. In order properly to distribute liquid film to the vertical channels formed by first corrugated film material 28, the density of second corrugated fin material 62 should be no greater than first corrugated fin material 28.

This plural-domain finning (described above) could be constructed from two regions of corrugated-fin material, the first region having a lower density of material than an underlying second region. Moreover, as men-

tioned above, such plural-domain distribution could be utilised alone or in conjunction with liquid film distribution designs other than slotted dividing bars 54.

Claims

1. A heat exchanger for exchanging heat between first and second fluids, said heat exchanger comprising:

a plurality of vertically oriented, spaced apart passage walls (10) defining a plurality of alternating first and second passages (12;14) located between said passage walls (10) to receive respectively said first and second fluids in an indirect heat transfer relationship;

first inlet and outlet means (20, 22, 24, 26; 30, 32, 34, 36) for respectively introducing and discharging said first fluid into and from said first passages (12);

second inlet means (42, 44, 46, 48, 50) for introducing said second fluid into said second passages (14) as a liquid;

slotted dividing bars (54) located between said passage walls (10) defining said second passages (14), said slotted dividing bars (54) having spaced, vertically oriented slots (58) to cause said liquid to flow against said passage walls defining said second passages (14), thereby to enhance formation of liquid film on said passage walls (10); and

second outlet means for discharging said second fluid from said second passages (14) after having indirectly exchanged heat with said first fluid.

2. A heat exchanger as claimed in claim 1, further comprising:

first corrugated fin material (28) located within the first and second passages (12;14) for forming vertically oriented channels for downflow of the liquid film

at least two sections, located above said vertically oriented channels and below said slotted dividing bars (54) and within said second passages (14), respectively containing second and third corrugated fin material (60;62);

said second corrugated fin material (60) being located above said third corrugated fin material (62); and

said third corrugated fin material (62) having a corrugation density higher than said second corrugated fin material (60) and no greater than said first corrugated fin material (28) to distribute said liquid film into said vertically oriented channels located within said second passages.

3. A heat exchanger as claimed in claim 1 or claim 2, wherein each of said slotted dividing bars (54) has a lengthwise extending peak (56) to cause said liquid to flow towards said slots (58).

4. A heat exchanger as claimed in claim 2 or claim 3, further comprising a fourth corrugated fin material (64) located between said second and third corrugated fin materials (60) and (62) and having an intermediate corrugation density between the corrugation densities of said second and third corrugated fin materials (60;62).

5. A heat exchanger as claimed in any one of the preceding claims, wherein there is a first row of slots (8) on one side of each dividing bar (54) and a second row of slots (58) on the other side thereof, the slots (58) in the first row being staggered relative to the slots (58) in the second row.

6. A heat exchanger as claimed in any one of the preceding claims, wherein said second passages (14) are open at a bottom region of said heat exchanger so as to provide said second outlet means.

7. A heat exchanger as claimed in any one of the preceding claims, wherein said first inlet means (20,22,24,26) comprises a manifold (20) for distributing said first fluid to said first passages (12), corrugated fin material (24) having horizontal corrugations for conducting said first fluid horizontally, and inclined corrugated fin material (26) having sloping corrugations for deflecting said first fluid from its horizontal flow direction.

8. A heat exchanger as claimed in any one of the preceding claims, wherein said passage walls (10) are provided by a plurality of spaced apart plates.

9. A heat exchanger as claimed in any one of the preceding claims, comprising inclined finning (30) for receiving said first fluid from said first passages (12) and deflecting the first fluid from a vertical to an inclined direction, and further finning (32) for conducting said first fluid along a horizontal path to an outlet manifold (34).

10. A heat exchanger for exchanging heat between first and second fluids, said heat exchanger comprising:

a plurality of vertically oriented, spaced apart

passage walls (10) defining a plurality of alternating first and second passages (12, 14) in indirect heat exchange relationship with one another for receiving said first and second fluids, respectively;

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first corrugated fin material (28) located within the first and second (12, 14) for forming vertically oriented channels for downflow of liquid film;

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first inlet and outlet means (20,22,24,26; 30,32,34,36) for respectively introducing and discharging said first fluid into and from said first passages (12);

15

second inlet means (42,44,46,48,50) for introducing said second fluid into said second passages (14) as a liquid;

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at least two sections, located above said vertically oriented channels and within said second passages (14), respectively containing second and third corrugated fin material (60,62);

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said second corrugated fin material (60) located above said third corrugated fin material (62);

said third corrugated fin material (62) having a corrugation density higher than that of said second corrugated fin material (60) and no greater than that of said first corrugated fin material (28) to distribute said liquid film into said vertically oriented channels located within said second passages (14); and

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second outlet means for discharging said second fluid from said second passages (14) after having indirectly exchanged heat with said first fluid.

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11. A heat exchanger as claimed in claim 10, wherein said second passages (14) are open at a bottom region of said heat exchangers so as to provide said second outlet means.

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12. A heat exchanger as claimed in claim 10 or claim 11, further comprising a fourth corrugated fin material (64) located between said second and third corrugated fin materials (60,62) and having an intermediate density between the corrugation densities of said second and third corrugated fin materials (60,62).

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FIG. 1

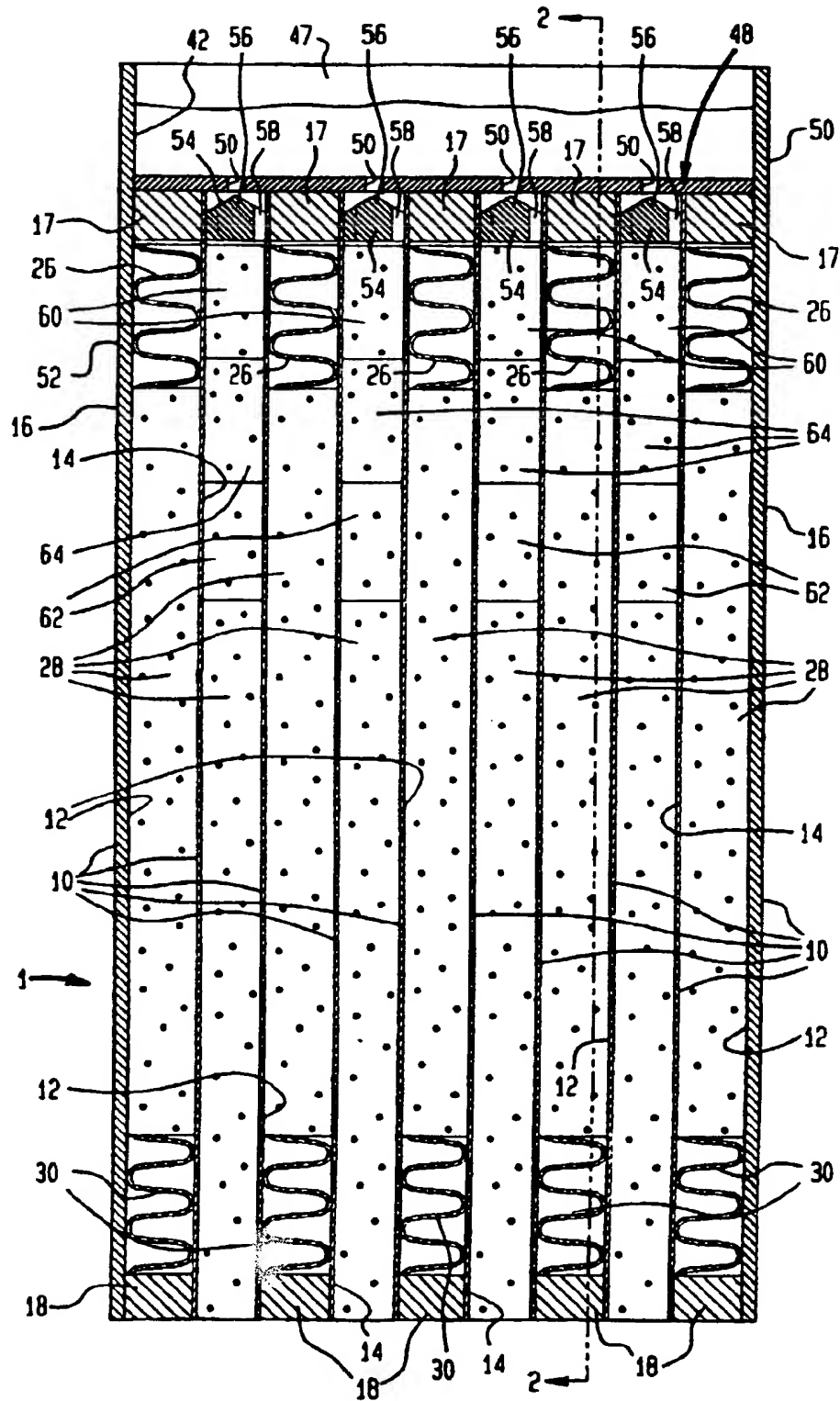


FIG. 2

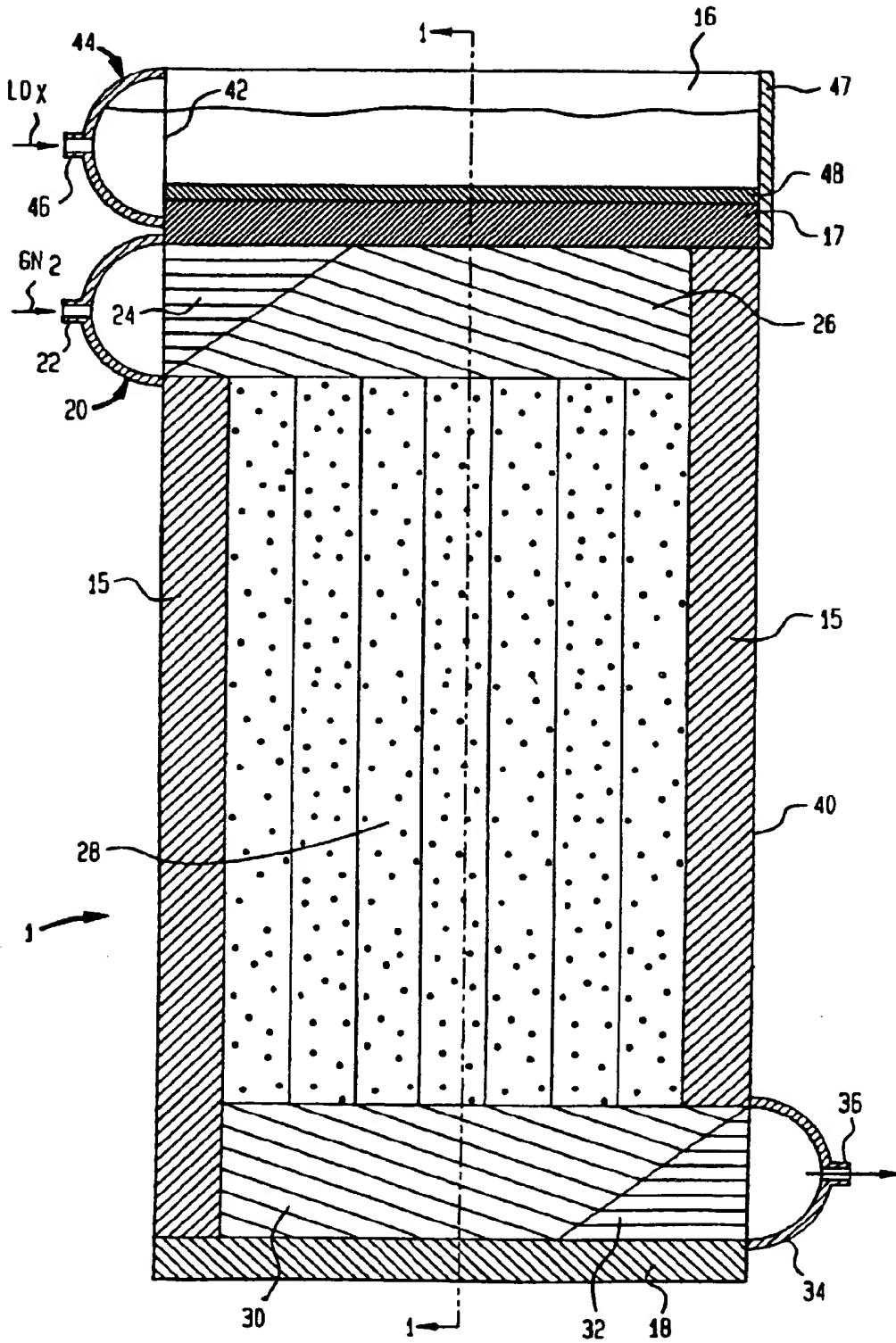
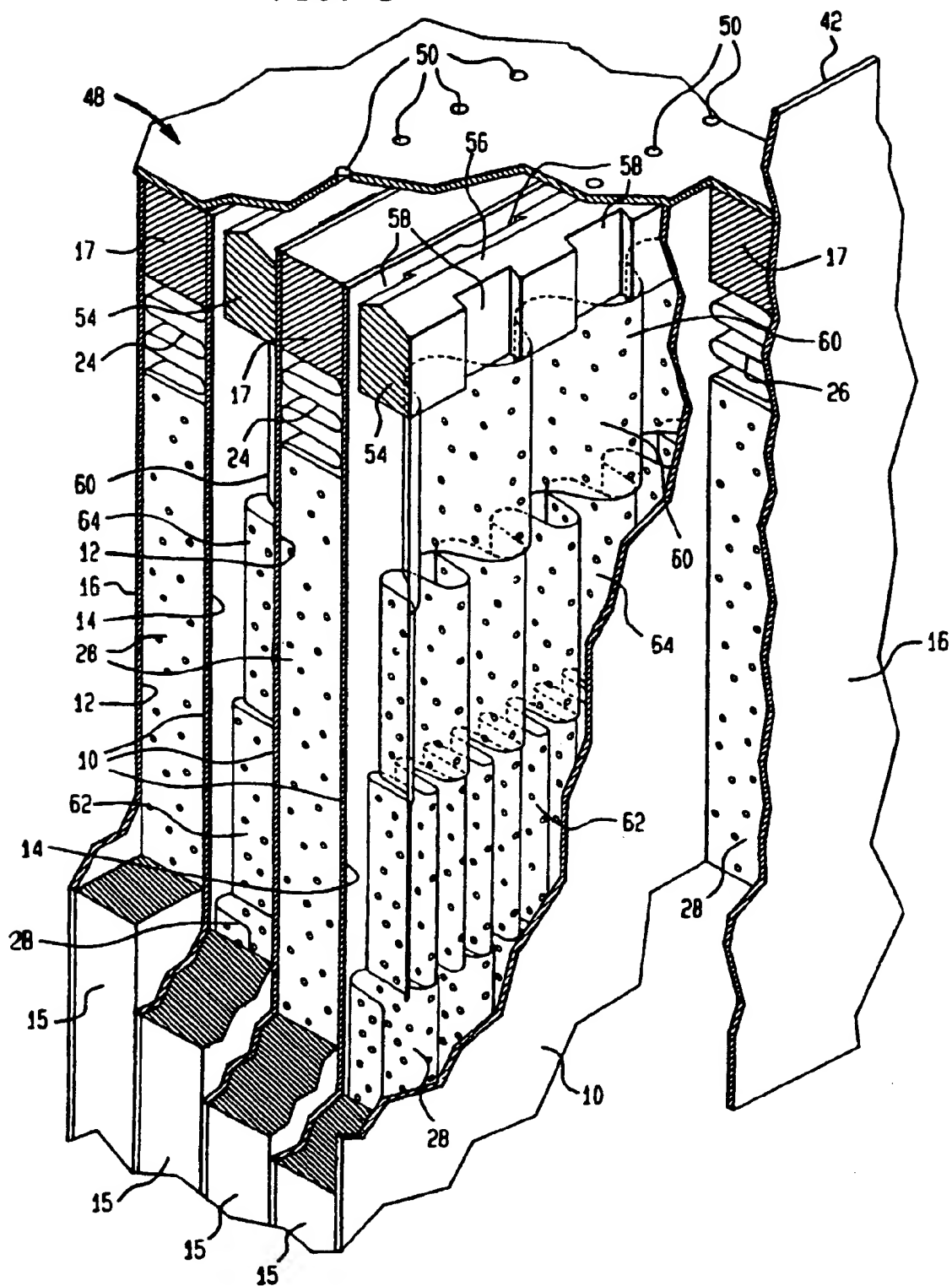
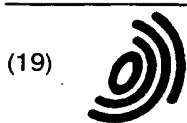


FIG. 3





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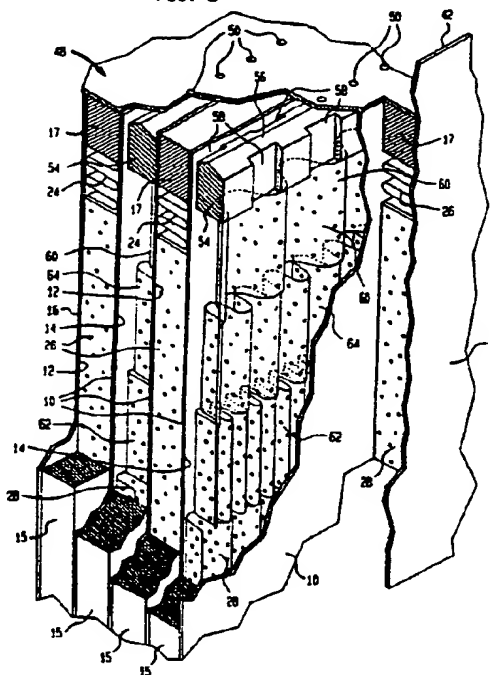
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FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 97 30 1747

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Y	GB 1 190 794 A (ROSENBLAD, CURT F.) 6 May 1970 * page 1, line 36 - line 76; figures 1.4 *	3	
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A	* column 3, line 37 - column 4, line 2; figures 3,5 *	2,4, 10-12	
X	US 4 398 596 A (LAURO FERNAND ET AL) 16 August 1983 * column 2, line 2 - line 7; figure 1 * * column 3, line 50 - column 4, line 7; figures 2,3 *	1	
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 29 December 1998	Examiner Mootz, F
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